A Bivariate Modelling of the Electricity Consumption-Financial Development Nexus for Ghana

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ABSTRACT

The current study modelled the long run and short run links between financial developments and disaggregate energy consumption (electricity consumption) in Ghana for the period 1970 to 2011 using Autoregressive Distributed Lad Model (ARDL). The findings of the study on the cointegration test indicate significant evidence of cointegration between electricity consumption and financial development. The findings seem to suggest that financial development is a key explanatory variable in electricity consumption management in order to attain sustainable energy consumption and economic growth. The issues of structural breaks in unit root and direction of causality should be consider in future studies.

Key words: Electricity consumption, financial development; cointegration; Long run
Jel codes: O13, O16, P28, P34, Q42, Q43

1 INTRODUCTION

The issue of finance in electricity demand has attracted a lot of attention in the energy literature following the initial works of Kraft and Kraft (1972) and continue to gain attention since there is inconclusive findings on the nexus between electricity consumption and finance (Kakar, Khilji, & Khan, 2011; Shahbaz et al., 2011). Electricity as energy source is very important in the functioning of an economy since electricity allows the main players (Government, firms, and households) to carry on with their various activities. Sustainable economic growth and poverty reduction are considered as a function of sufficient electricity supply in an economy. As the world population continues to increase, electricity consumption is expected to increase and as such, empirically examining the main key explanatory variables in electricity consumption is essential.

The findings of empirical works on the finance-electricity nexus are reported in the works of (Muhammad, 2011; Sadorsky, 2011; Rashid, 2015). Though there are many empirical works in the literature on the financial development-energy consumption nexus (Dan & Lijun, 2009; Bartleet & Gounder, 2010; Sadorsky, 2010, Faridul et al., 2011; Kakar, Khilji, & Khan, 2011; Mehrara & Musai, 2012; Yeboah, 2017), very few works exist on the link between financial development and electricity consumption in disaggregate analysis.

The very few empirical works on the role of financial development in electricity consumption indicate there is effect of financial development on electricity consumption. For example, Sadorsky (2011) reported that financial developments increases the demands of big tickets an economy, and hence increase in electricity consumption. Muhammad (2011) used the ARDL bounds testing approach to cointegration over the period 1971 to 2009 for Pakistan. The findings support the existence of cointegration among the variables in the estimated model. The findings of the vector error correction (VECM) Granger causality test for the direction of causality among the variables indicates that feedback hypothesis between financial development and electricity consumption.

Rashid (2015) examined the financial development-electricity consumption-growth nexus for Pakistan using annual time series data for the period 1975 to 2011. The analysis was based on cointegration method and VECM. The cointegration results indicate significant long run relationship among the variables. The results show significant negative relationship between financial development and electricity consumption. The results on the direction of causality indicate causality run from electricity consumption to financial development.

The review indicates very few empirical studies on disaggregate energy consumption and financial development and the current study fills in the gap. The objective of the paper is to model and examine the effect of financial development on electricity consumption for Ghana in order to contribute to the empirical literature on energy consumption. The research question underlying the paper is what is the effect of financial development on electricity consumption in both short run and long run? The paper is based on the assumption that, financial development have(has) significant effect on electricity consumption in the short run and long run.

Financial development is proxied by money supply and not other variables such as bank deposit or stock variables. The findings are limited by the limitations of the estimation methods such as the Augmented Dickey-Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and the ARDL methods, as well as the challenges of secondary data used. The rest of the paper looks at the methodology, the empirical results, and conclusions.

2 **METHODOLOGY**

2.1 Estimation Method

The stationarity properties of the data (financial development, and electricity consumption) were investigated using the Augmented Dickey-Fuller (ADF) stationarity test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity tests. The null hypothesis of the KPSS test is that there is stationarity around a deterministic trend (trend-stationary) against the alternative hypothesis that the variables are none-stationary. The null hypothesis of the ADF test is that the data set are stationary in levels whereas the alternative hypothesis is that the data set are not stationary in levels. The long run and short run relationships between financial development and electricity consumption is (was) tested using the ARDL estimation method. The ARDL model is suitable for small data set and can be applied whether the stationarity properties are known or unknown.

2.2 Data

The data for the empirical verification is based on annual secondary data on financial development (proxied by money supply), and electricity consumption for Ghana for the period 1970-2011. The source of the data is the World Bank database. The sample size for the study is 54 which is considered as large since it is larger than 30.

Table 1 Data Description, Proxies and Sources

Data Description	Source
Financial Development (M2) is proxied by Money Supply	World Bank World Development Indicator (WDI)
Electricity Consumption (EC)	World Bank World Development Indicator (WDI)

2.3 Conceptual Framework and the Empirical Model

The effect of financial development and electricity consumption is modelled for Ghana to determine whether financial development affects electricity consumption in the long run and short run. The relationship between financial development and electricity consumption is (was) modelled in the current study in a bivariate model as indicated in equation (1). The dependent variable in the model is electricity consumption (EC) whereas the explanatory variable in the model is financial development (M2). The model is as specified in log-linear form in equation (1).

$$\ln EC_t = \ln M2_t + e_t \text{...}(1)$$

3 EMPIRICAL RESULTS

3.1 Analysis of Descriptive Statistics

The results of the summary statistics of the variables are shown in Table 2. The mean measures the central tendency of the series variables and the values indicate a good fit. The volatility of the series variables are measured by the coefficient of variation. The nature of the distribution is measured using the coefficient of skewness. The series distributions are normal and asymmetric. The types of the skewness are positive and negative. The range of the coefficient of skewness is between positive one (1) and negative one (-1).

The results of the summary statistics of the variables as shown in Table 2 indicate that electricity consumption falls(fell) as low as 92.359GWh and rise (rose) as high as 421.233GWh. Financial development variable also falls (fell) as low as 11.305 and (rose) as high as 34.108. The mean measures the central tendency of the series variables and the values indicate a good fit. The volatility of the series variables are was measured by the coefficient of variation.

Of the two variables, the most volatile is was electricity consumption (15.308) followed by financial development variable (0.278). The nature of the distribution of the series is was measured using the coefficient of skewness. The series distributions are normal and asymmetric. The types of the skewness are positive and negative. In a positive distribution, the asymmetric tail moves towards the right. In a negative skewness, the asymmetric tail moves to the left direction. Hildebrand (1986) stated that an absolute value of coefficient of skewness greater than 0.2 indicates greater skewness. The range of the coefficient of skewness is between positive one (1) and negative one (-1). Electricity consumption is was negatively skewed whereas financial development variable is positively skewed.

The nature of the peakness of the series variables was measured using the coefficient of kurtosis (Pearson, 1905). There are three forms of the nature of peakness. They are platykurtic (more flat-topped distribution- γ<0); leptokurtic (less flat-topped distribution-γ>0) and leptokurtic (equally flat-topped distribution- γ=0). A higher coefficient value of kurtosis is an indication of more extreme observation or the distribution is more single-peaked. The coefficient value of the kurtosis of the financial development variables (-0.972) is less than zero (0) which indicates more flat-topped distribution. The coefficient value of the kurtosis of the electricity variable (0.867) is was more than unity (1) which indicates less flat-topped distribution.

Table 2 Summary Statistics, using the Observations 1970-2011

Vars.	Mean	Min	Max	SD	CV	SK	KUR
EC	311.580	92.359	213.630	71.435	15.308	-0.897	0.867
M2	22.446	11.305	34.108	6.239	0.278	0.033	-0.972

Source: Author’s computation, 2013/2014. SK=Skewness; KUR. =Kurtosis; CV=Coefficient of Variation; Min. Minimum; Max. =Maximum; SD=Standard Deviation

3. 2 Results of Autoregressive Distributed Lag (ARDL) Bound Approach to Cointegration for Electricity Consumption and Financial Development

The results reported in Table 3 indicates significant cointegration between electricity consumption and money supply since the calculated F-statistics of 37.2010 in model 1 and 6.9700 of model 2 are greater than the critical values of the upper bounds at the 90%, 95% and 99% levels of significance. The null assumption of no cointegration was rejected in model 1 and 2. The results indicate that money supply is a long-run equilibrium variable that explains electricity consumption during the period under discussion.

Table 3 Test for cointegration relationship

Critical bounds of the F -statistic: intercept and trend						
Models	90% level		95% level		99% level	
	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
	2.915	3.695	3.538	4.428	5.155	6.265
	Computed F - Statistic		**Decision**			
1. F_{EC}(EC/M2)	37.2010***		**Cointegrated**			
2. F_{M2}(M2/EC)	6.9700***		Cointegrated			

Source: Author's computation, 2013/2014. Note: critical values were obtained from Pesaran et al., (2001) and Narayan, (2004).

NB: *** denotes significant at 1%

3.3. Results of Long-Run Elasticities of ARDL Model

The long-run determinant of electricity consumption was estimated using the model in which electricity consumption is the dependent variable. The results are reported in Table 4. The results indicate that money supply statistically significantly determine electricity consumption in the long run. The coefficient of money supply has expected a priori theoretical sign which is positive. This means in the long run, increase in money supply leads to increase in electricity consumption, other things equal.

Table 4 Estimated long-run coefficients. Dependent variable is $lnEC$

Variable	Coefficient	Std. Error	T-ratio	P-value
Constant	4.3216	0.52884	8.1719	0.000
Trend	-0.013238	0.0049683	-2.6646	0.012
lnM2	0.54805	0.18664	2.9365	0.006***

Note: *** denotes statistical significance at the 1%. ARDL (1) selected based on Akaike Information Criterion

3.4. Results of Short-Run Elasticities of ARDL model

The results of short-run dynamic equilibrium relationship coefficients estimated with trend, intercept and error correction term (ECM) are reported in Table 5. The results on the nature of the short run coefficients are not different from that of the long-run coefficients. Money supply is significant determinant of electricity consumption in the short run. The error correction mechanism serves as a means of reconciling short-run behaviour of an economic variable with its long-run behaviour. The error correction term (ECM) is statistically significant at 1% level of significance and have the theoretical expected sign, which is negative. The coefficient of -0.60575 indicates that, after 1 percent deviation or shock to the system, the long-run equilibrium relationship of electricity consumption is quickly re-established at the rate of 60.6% percent per annum. The value does indicate stronger adjustment.

Table 5 Short-run representation of ARDL model. ARDL (2) selected based on Akaike information Criterion. Dependent variable: $\Delta lnEC$

Variable	Coefficient	Standard error	T-statistic	P-value
Constant	2.6178	.65825	3.9770	0.000***
Trend	-.0080191	.0033750	-2.3760	0.000***
$\Delta lnEC_{-1}$	0.48933	0.14108	3.4683	0.001***
ΔlnM2	0.33198	0.12575	2.6401	0.012**
ecm (-1)	-0.60575	0.12506	-4.8435	0.000***
ecm = LNEC -4.3216C + .013238T -.54805LNM2 ……………………(2)				
R-Squared 0.66316 R-Bar-Squared 0.62353				
S.E. of Regression 0.18342 F-stat. F(4, 34) 16.7344[0.000]				
Mean of Dependent Variable 5.7033 S.D. of Dependent Variable 0.29894				
Residual Sum of Squares 1.1439 Equation Log-likelihood 13.4791				
Akaike Info. Criterion 8.4791 Schwarz Bayesian Criterion 4.3202				
DW-statistic 1.9007				

Source: Author's computation, 2013/2014. Note: ** and *** denotes statistical significance at the 5% and 1% levels respectively

3.5. Results of Diagnostic Tests

The diagnostic tests of the short-run estimation to examine the reliability of the results of the error correction model are reported in Table 6. The null hypothesis of no serial correlation could not be rejected using the Lagrange multiplier test and the F-statistics. The RESET test showed evidence of incorrect functional specification of the model through a rejection of the null hypothesis. The estimated model did not pass the normality test. The model passed the Heteroscadasticity test indicating the variances are constant over time. The R^2(0.66316) and the adjusted R^2 (0.62353) are not an indication of a very well behave model. The coefficients indicate approximately 66.32% of the variations in electricity consumption are attributed to the explanatory variable.

Table 6 Short-Run Diagnostic Tests of ARDL Model

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(1)= 0.3332[0.564]	F(1, 30)=0.2844[0.597]
B:Functional Form	CHSQ(1)= 2.0836[0.149]	F(1, 30)= 1.8626[0.182]
C:Normality	CHSQ(2)= 4.0220[0.134]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 7.3369[0.007]	F(1, 37)=8.5735[0.006]
A:Lagrange multiplier test of residual serial correlation B:Ramsey's RESET test using the square of the fitted values C:Based on a test of skewness and kurtosis of residuals D:Based on the regression of squared residuals on squared fitted values		

Source: Author's computation, 2013/2014.

The stability of the long-run estimates was determined by employing the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) procedures. This was determined using the residuals of the error-correction model indicated by equation (5.1). The CUSUM test of stability determines the methodological arrangements of the estimates and its null hypothesis states the coefficients are stable. The null assumption is rejected when the CUSUM surpasses the given critical boundaries, which demonstrate unstable nature of the estimates. The CUSMSQ determines the stability of the variance. Both tests as shown Figure 1 and 2 revealed that the estimates and the variance were stable as the residuals and the squared residuals fall within the various 5% critical boundaries. The null assumptions are rejected in both tests.

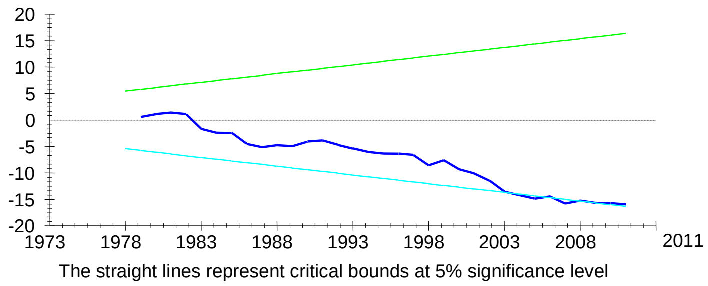

Figure 1: Plot of cumulative sum of recursive residuals

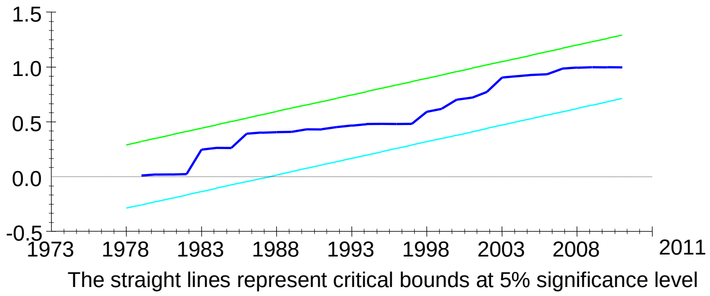

Figure 2: Plot of cumulative sum of squares of recursive residuals

4. CONCLUSIONS AND POLICY IMPLICATIONS

The aim of the study is was to model and examine the effect of financial development on electricity consumption for Ghana using data set from 1970-2011. Both the ADF and KPSS tests were used to examine the unit root properties of the data set. The results of the unit root test indicate the data set are integrated of order one. The ARDL method of cointegration was applied to examine the long run and short run effect of financial development on electricity consumption.

The findings overwhelmingly showed that financial development is cointegrated with electricity consumption. There is significant long run and short run relationship between financial development and electricity consumption. The findings are consistent with those of Muhammad (2011); Sadorsky (2011); and Rashid (2015) who examined the effect of financial development on electricity consumption and determined that financial development is cointegrated with electricity consumption, indicated significant long run nexus between the two variables.

The finding of the study seem to suggest that financial development can be relied on to manage electricity consumption to ensure sustainable energy consumption in Ghana since financial development is a key explanatory variable in electricity consumption.

Future study should consider disaggregating financial development in the analysis to include other variables from the stock market. The effect of structural breaks should also be considered as well as the issues of causality.

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